PROBLEMS IN PLANT ENDEMISM ON THE COLORADO PLATEAU

Stanley L. Welsh[1]

Abstract.—The problem of distribution of plant endemics is explored, especially as regards distribution of these plant species on elevational and substrate bases. Endemics per unit area are greater at elevations above 1980 m and on finely textured soils. A summary of data and a list of references is presented.

The Colorado Plateau has long been known as a center for endemic plants. The basis for that endemism most certainly involves the unique features of the Plateau Province, especially as regards climate, geological history, and position along migratory routes. Each of these features has played a role, and the interpretation of the nature of endemism in the region must reflect the part each has played. Climate is considered as arid for the region generally, but the mountains within and bordering the Province stand as moist discontinuities in this arid middle portion of the Colorado River drainage system. Geology is, in large part, displayed in technicolor, with Mesozoic and Cenozoic strata dominating, and with the thin cover of vegetation hardly obscuring the geology. Only at higher elevations is the mantle of vegetation sufficiently dense as to cloak the geological substrate. Volcanic intrusives and extrusives are limited in area. Sedimentary formations constitute the main features of the plateau region.

Canyons of grand size are entrenched into the surfaces of the uplifted plateau, where formations are displayed along the margins of horizontal or gently dipping plateaus. Broad anticlines, synclines, or gentle to steeply plunging monoclines have been eroded to expose hogbacks or cuestas where vast stratigraphies are exposed in relatively short distances.

Main migratory routes into the plateau involve the mountain sequences in the Rocky Mountains along both the eastern and western margins. The great river system has provided a lane for movement of propagules both up and down stream. Great Plains influence appears to have been mainly from the southwest. Hence, the flora of the plateau is a function of the sources of its plants; Mohavean, Chihuahuan, Great Plains, Rocky Mountain, Great Basin, etc.

My own interest in plant endemics within the Colorado Plateau began more than two decades ago when I began research leading to a thesis on the vegetation of the Utah portion of Dinosaur National Monument (Welsh 1957). The geological control of vegetation at lower elevations in the plateau is readily apparent, but nowhere so overwhelming as along the margins of the Split Mountain anticline at Dinosaur National Monument. The interaction of various substrates to low annual precipitation through long periods of time has led to the demonstration of edaphic differences on a grand scale. Soil formation in a traditional sense is unknown. The substrate surface is often merely residual parent material only slightly modified from that a few inches below the surface. Alluvium and colluvium function differently from residual or parent materials.

Conditions for growth on the substrates

[1]Life Science Museum and Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602

available are often rigorous at best. Frequently, those plants capable of establishment and reproduction are few in number. Competition is therefore limited, with the harsh environments supporting very few higher plant species.

This point is illustrated by a statement ascribed to the venerable Walter P. Cottam concerning vegetation of the Mancos Shale formation. While camped on that formation, he is reported to have stated that, "there were only four species of plants growing here, and I don't know three-fourths of them." This statement, whether true or not, is indicative of the paucity of vegetation on some of the formation, and of the peculiar nature of some of the entities growing there.

Worst possible substrates available are the clays derived from saline shales such as members of the Mancos Formation and its counterparts such as the Tropic Shale (Tununk equivalent). Salt contents of 30,000 ppm are not uncommon. Additionally, the clays perform in a special manner when water is added. A rainstorm of some six hours' duration supplied from 2 to 6 inches of water in June 1972 to the Tropic Shale east of Glen Canyon City in Kane County, Utah. Penetration into the clay of the Tropic Shale did not exceed 2 inches. Even when wet to field capacity the clays provide very little moisture for plant growth. Still, a few plants do grow on this substrate, some of them continuing to flower and to mature fruit at soil moisture levels below the arbitrary 15 atmosphere level accepted as the permanent wilting point.

At higher elevations, where rainfall is greater, even these substrate types are overwhelmed by vegetation and a soil mantle is developed which eventually is effective in insulating the vegetative cover from the effects of high salinity and from such substances as selenium.

Sandstones and their derivatives form the other extreme in edaphic situations. Soluble salts are fewer, selenium is more restricted, water penetration is greater, and the proportion of water which can be extracted from soil at field capacity is greater. Increased species diversity on sands is apparently a function of the greater ease of establishment and better all-around water and soil relationships, given equal elevation, temperature, humidity, and opportunity for establishment.

Glaciation has apparently not played a major role in the plateau, except in the highlands along its fringes. Persistence of plants through the Pleistocene has been a possibility in at least the lower elevation portions, and indeed in most of the Plateau Province.

With this background, it seems both feasible and necessary to attempt to quantify the data on endemism. The data have been generated from information recorded on herbarium labels of specimens deposited at Brigham Young University and at the National Museum of Natural History, Smithsonian Institution. Further data have been taken from various taxonomic treatments (see list of references). Despite all attempts, the information available is fragmentary, and the conclusions derived from that information must be regarded as tentative. A portion of the problem involves the nature of endemics generally. Some of them are highly restricted and they have been collected only once or a very few times. Information on substrate, elevation, geological formation, and other pertinent information is not available either on the herbarium materials or in the literature. Further, most plant taxonomists (and others who collect plants) are not well prepared in identification of substrate types. The clays and silts of some investigators will be the sands and gravels of others. Despite the shortcomings of the information, there seem to be trends which can form the basis for further investigations.

The data summarized from the sources investigated are presented in Table I. Only 34 families of vascular plants are known to have endemic species in the region. The total number of endemic entities is some 340, an average of about 10 per family. The endemics are far from equally divided among the various families. The Boraginaceae (20), Compositae (58), Leguminosae (86), Polygonaceae (28), and Scrophulariaceae (29) contain some 221 species or about 65 percent of all endemic taxa. The greatest number of taxa occurs in the Legume family. The 86 entities constitute some 25 percent of all of those in the region.

The genus *Astragalus*, with 62 endemic taxa, is not only the largest single contributor to the list of endemics, but contributes a greater number of taxa than any family beside the legumes. Most of those taxa occur at low elevations, contributing to the

Table 1. Summary of plant endemics on the Colorado Plateau

Family Name	Taxa No.	Substrate C, S, M	Sand, G	Both	NA	Elevation 1980 m <6500 ft	1980m >6500 ft	Both	NA
Apocynaceae	4	1	3	1		4			
Asclepiadaceae	4		2	2		2	1		
Boraginaceae	20	3	7	10		9	3	4	4
Cactaceae	11	2	1	2	6	5			6
Capparidaceae	1			1		1			
Caryophyllaceae	1	1					1		
Chenopodiaceae	6	2	2	1	1	4		2	
Compositae	58	9	29	4	16	25	12	7	14
Cruciferae	11	6	3	2		7	4		
Cyperaceae	5		3		2	2	3		
Elaeagnaceae	1		1					1	
Ephedraceae	1		1			1			
Euphorbiaceae	1	1				1			
Gramineae	2		2				2		
Gentianaceae	2			1	1	1		1	
Geraniaceae	1		1				1		
Hydrophyllaceae	12	6	3	1	2	9		1	2
Labiatae	2			2		1	1		
Leguminosae									
Astragalus	62	18	35	9		42	16	4	
others	24	5	17	1		16	4	3	1
Liliaceae	4		4			3	1		
Najadaceae	1		1				1		
Nyctaginaceae	2		2			2			
Onagraceae	9	3	6			6	2	1	
Papaveraceae	1		1			1			
Polemoniaceae	13	3	10			5	5	2	1
Polygonaceae									
Eriogonum	27	14	12	1		17	8	2	
Other	1		1				1		
Portulacaceae	1		1			1			
Primulaceae	1		1			1			
Ranunculaceae	6		6				4	2	
Rosaceae	1		1			1			
Rubiaceae	2		2			1		1	
Scrophulariaceae	29	7	21	1		8	13	8	
Selaginellaceae	1		1			1			
Umbelliferae	12	3	9			5	5	2	
Total	340	84	187	40	29	182	88	41	29
Percentage		24.7	55.0	11.8	8.5	53.5	25.9	12.1	8.5

Abbreviations: C, clay; S, shale, M, mud; G, gravel; NA, not available.

idea that endemism is especially great at low elevations. Despite this apparent abundance of endemics at low elevations, only slightly more than half of the entities are known from below 1980 m (6500 feet) in elevation; a quarter of them occur above 1980 m (6500 feet), 12 percent overlap, and 8.5 percent are unknown. However, the total land area above 1980 m in elevation represents only about 30 percent of the region. When endemics are expressed in per unit area figures there is 1 endemic per 1170 km^2 for the higher elevations and 1 per 1318 km^2 below that elevation. Thus, the incidence of endemics generally is greater at the higher elevations.

The area of the Colorado Plateau is roughly 340,000 km^2 (133,000 sq mi), which places the density of endemics at about 1 per each 1000 km^2. Almost half (55%) of the endemics occur on sand and gravel, and a quarter on clays, shales, or muds. Those that grow on both types constitute only 11.8 percent, and data is missing for some 8.5 percent.

It is difficult to derive data on the proportions of sands and gravels to other substrate types. Certainly the sands and gravels cover more of the land surface than do the other substrate types. If one assumes that only a quarter of the included region consists of clays, shales, and muds, then the endemics on clays occur at about 1 per 1000 km^2. Those on sands and gravels are present at a density of only 1 per each 1350 km^2.

Initial impressions by collectors that endemics are especially rich on the finely textured soils are supported by the fabricated data. Certainly if the total area occupied by clays is less than 25 percent, then the endemics per unit area might be expected to be very great indeed. Surprising is the greater density of endemics in the montane sections of the plateau. Distribution of endemics is hardly at random, and any attempt to provide averages or taxa per unit area is likely to obscure the geographic controls which result in the development and placement of the taxa.

In a previous paper (Welsh, Atwood, and Reveal 1975), the endangered, threatened, extinct, endemic, and rare or restricted vascular plants of Utah are plotted by geographic subdivision of the state. The large part of those plants represent endemic plants of Utah. Instructive from the plotting is the apparent unequal distribution of those plants in the state. Main centers of distribution include the high plateaus of south central Utah, the Canyonlands section, and the Uinta Basin. A trend is present, however, which indicates that the greater numbers occur near the southern end of Utah, with progressively fewer taxa northward.

Since endemic plants are likely to be considered as endangered or threatened, and since most of the lands within the Colorado Plateau are federally controlled, then some management of these specialties is indicated. Perhaps it is possible to establish some predictive guidelines with regard to location of endemics (i.e., where they might be expected to occur). Outcrops of shale, mudstone, and siltstone at all elevations should be considered as suspect sources for plant endemics. Any peculiar substrate, such as the lacustrine limestones at higher elevations in the western margin of the plateau, should be considered as important localities for endemic taxa. Glaciated localities can generally be excluded from consideration in management practices.

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